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MONITORING RESULTS OF THE PORT MAITLAND CONTOUR TRENCH B SEPTIC WASTE DISPOSAL SYSTEM

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by

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PREFACE AND ACKNOWLEDGEMENTS

This study was conducted by Porter Dillon Limited for Canada Mortgage and Housing Corporation and describes the performance results of a new concept and engineering design in soil absorption sewage disposal systems.

Porter Dillon Limited acknowledges the financial assistance provided by CMHC and the Nova Scotia Department of Health. The principal funding was provided by CMHC with the Provincial Health Department assuming the responsibility for analytical costs.

This report was prepared under the guidance of a Steering Committee comprised of representatives from Canada Mortgage and Housing Corporation, Environment Canada, and the Nova Scotia Department of Health. Special thanks go to Mr. Peter Casey and to Mr. David Pask of the Nova Scotia Department of Health and to Mr. Al Townshend of Environment Canada for their interest and technical assistance provided during the course of this study.

Porter Dillon Limited wishes to thank all of those individuals who participated in the preparation of this publication and hopes that this work contributes to the Canadian literature in this field.

EXECUTIVE SUMMARY

Introduction

The Port Maitland Contour Trench sewage disposal system represents a radical departure in soil absorption systems. Designed to cope with the problem of inadequate sewage disposal systems, common throughout Nova Scotia because of poor soil permeability and the geological characteristics of the province, the system incorporates on-site servicing but off-site disposal.

New provincial legislation was required to permit the creation of municipally owned and operated utilities for managing this new type of wastewater disposal scheme, and in 1982 Port Maitland became the first Wastewater Management District in Nova Scotia. The District is served by four separate systems, each with its collector sewers, septic tank for sedimentation treatment, siphon dosing chamber and contour trench for effluent ground disposal. The entire system operates by gravity.

Canada Mortgage and Housing Corporation, in its role of supporting new technology developments to improve housing quality, agreed to fund the monitoring program required to determine the operating performance of the new system. The Nova Scotia Department of Health provided funding for sample analysis.

Objectives

To assess, through water level measurements and laboratory evaluation of water samples from the system, the following:

- hydraulic response to effluent loading of a contour-trench septic-waste disposal system and the related shallow groundwater flow regime;
- effectiveness of the contour trench in treating effluent;
- design criteria of the new trench and possible modifications for future applications.

Design

The contour trench system consists of distribution pipes in trenches placed along a constant elevation or contour for distances of 200 to 300 meters and perpendicular to slopes of 5 to 15 degrees. The siphon chamber periodically discharges enough septic tank effluent to fill one of the distribution pipes approximately four times a day. The other pipe rests for approximately a six month period.

For the monitoring study, a series of 18 single and multi-level monitoring piezometers were placed along the length of Contour Trench "B" at Port Maitland, and in profile perpendicular to the trench. The multi-level piezometers were used for detailed hydraulic measurements and water sampling.

In total, 8 complete sets of hydraulic data and 7 water quality sample series were collected during the two year period of the study.

Trench "B" was constructed in a low-permeability compact silty till and in conditions of shallow groundwater flow - the same physical limitations that caused problems to the many conventional septic systems in the community.

Results

In spite of changing saturation conditions within the contour trench, which make the hydraulic gradients highly variable, a general flow pattern is apparent. The system operates under the influence of a shallow hydraulic mound. As the siphon recharges the trench, the effluent mounds over the trench and dissipates downslope under strong lateral gradients. The effect of the mound is to increase the hydraulic gradients in the area of the trench, thus enlarging the effluent-soil contact area. The result is an improved effluent transfer from the trench to the soil media.

The evidence illustrates that the contour trench will continue to perform its design function despite the extreme surface infiltration and shallow soil saturation conditions encountered. A problem of periodic effluent breakout, via backflow to the interceptor trench, during prolonged wet weather conditions or spring runoff illustrates the need for re-design of the interceptor trench and reconsideration of the function it performs.

Conclusions

The Port Maitland contour trench system performed well during the two year monitoring period confirming, in principle, the value of contour trench disposal.

The data suggests that the shallow groundwater flow system and the soil medium provide a high degree of effluent treatment.

The data further suggests that the contour trench may operate under cyclic aerobic, anaerobic conditions.

Surface infiltration presents critical conditions within the trench during prolonged wet periods. Comprehensive surface vegetation regeneration and overland runoff control will be necessary in any new systems to reduce infiltration.

Further research is required to confirm conditions where anaerobic digestion may result in clogging of the trench-soil interface due to formation of bacterial slime.

The contour trench disposal system is worth examining for additional applications. It offers numerous advantages in terms of capital construction costs and operating expenses in relation to conventional treatment technology and provides one solution to a common problem of sewage disposal in rural areas across Canada.

1.0 INTRODUCTION

The Port Maitland Contour Trench sewage disposal system represents a radical departure in soil absorption disposal system design and construction procedures and is believed to be the first of its type in Canada.

On September 30, 1980, an agreement was signed between H. J. Porter & Associates Limited (now Porter Dillon Limited) and Canada Mortgage & Housing Corporation implementing a monitoring program. The Nova Scotia Department of Health entered into the agreement by providing for all analytical services. A project steering committee was selected from Canada Mortgage & Housing Corporation, Environment Canada and the Nova Scotia Department of Health.

The Port Maitland disposal system design was developed by H. J. Porter & Associates out of economic necessity, following exhaustive engineering review of central disposal and treatment methodologies and conventional soil absorption systems. The concept involves the clustering of groups of homes, commercial and public facilities which connect to shallow buried small diameter central collector mains and two high volume septic tanks set in series. The septic tank effluent flows to a downstream high volume twin siphon chamber. The siphons periodically discharge clarified sewage effluent to a unique system of trenches which follow a given elevation or surface contour for distances of 200 to 300 m and set perpendicular to a 5 to 15% slope. The hydraulics of the system are so designed to allow distribution of a given volume of effluent evenly over the length of a single trench, allowing the effluent to be discharged to the soil medium along a broad front.

1.1 Objectives

The original objectives of this study were twofold. 1) Assess the effectiveness of on-site sewage disposal systems in solving the pollution problem in Port Maitland and 2) Assess the effectiveness of the Municipal Management entity responsible for the overall management of the wastewater systems in Port Maitland.

The Port Maitland system was not constructed until late 1982. In the interim the Nova Scotia Department of Health developed a procedure which essentially dealt with the latter of these 2 objectives. During the construction phase the soils were found to be much more highly variable in texture, grain size and permeability than anticipated. The very low percolation rates of the soil encountered at the contour trench B site provided an excellent opportunity to evaluate the contour trench system in less than optimum soil conditions. As a result, efforts were redirected toward a detailed evaluation which focused on the operational characteristics of the contour trench system. Cost escalation over the 2 year period which lapsed between the submission of the original study proposal and the construction of the system, also entered into the decision to evaluate one trench system. The objectives were revised to the following:

a) determine the hydraulic response of the contour trench and shallow groundwater flow regime to effluent loading;

b) establish the effectiveness of the contour trench to treat effluent;

c) evaluate design criteria of the trench and outline modifications for future applications.

2.0 LOCATION

The community of Port Maitland is located 17 km north of the Town of Yarmouth in the County of Yarmouth, Nova Scotia (Figure 1). The present community is rural with a population of approximately 360 persons residing in dwellings arranged linearly along Highway No. 1 (Figure 2). Aside from dwellings, the community has a post office, service station, volunteer fire hall, elementary school, fish processing plant, community hall, heavy equipment dealer and garage, two churches, two general stores and several tourist related businesses.

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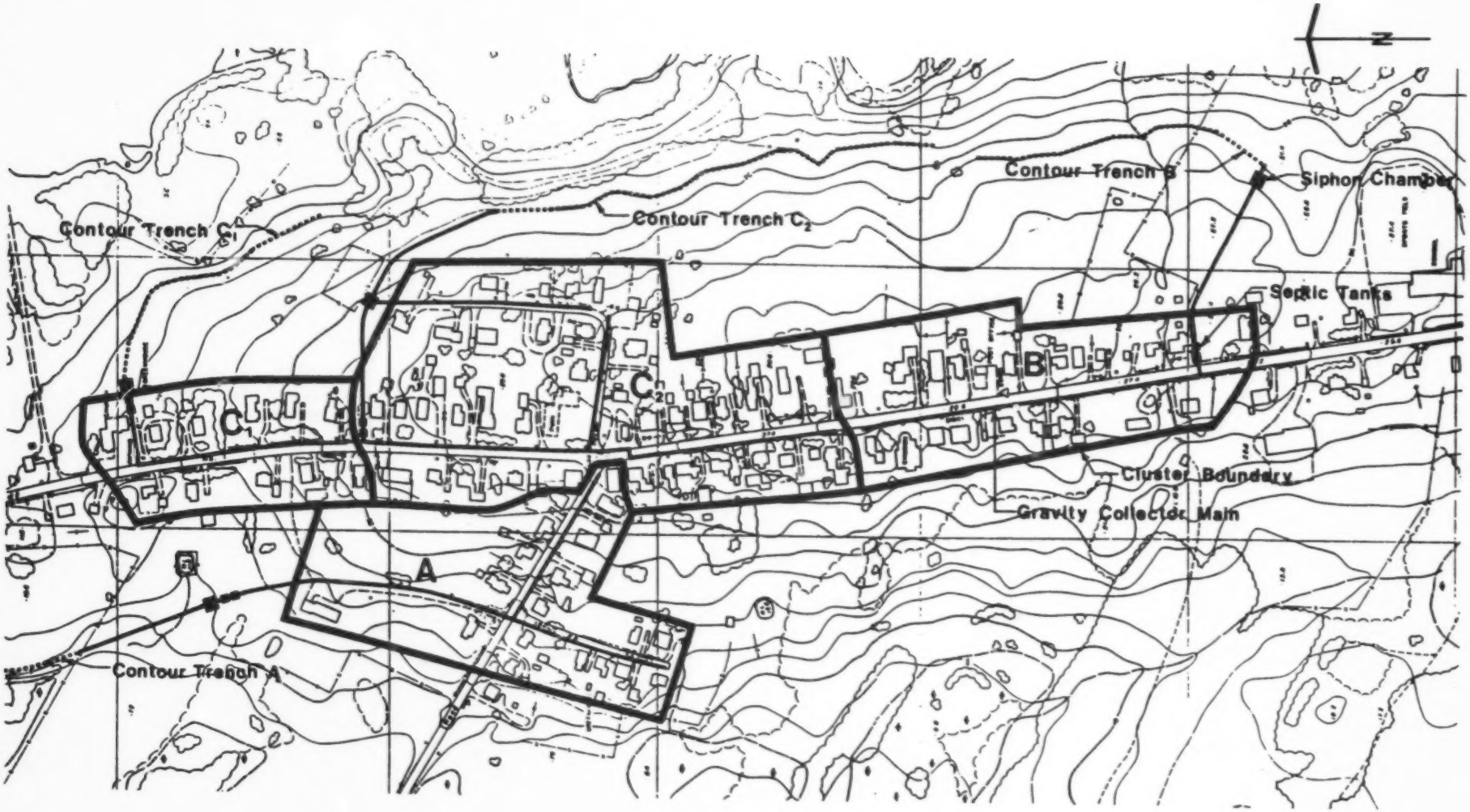
REGIONAL LOCATION
FIGURE 1



PORT MAITLAND COMMUNITY
AND CONTOUR TRENCH SYSTEMS

FIGURE 2

3.0 HISTORY OF THE PROJECT

The search for a solution to sewage disposal in the community of Port Maitland arose from a study conducted by H. J. Porter & Associates Limited in 1978. The study was initiated to assess the servicing needs of five specific communities within the Municipality of the District of Yarmouth. This servicing project was sponsored by the Nova Scotia Department of the Environment as part of a continuing series of studies related to the needs for water supply and sewage services in various communities throughout Nova Scotia.

The goals of that project included determination of existing levels of pollution and methods of servicing, determining population growth potential, assessment of the need for new sewage disposal systems and recommendations regarding the most economic and environmentally acceptable servicing systems, taking into consideration both conventional, central and on-site services.

Inadequate sewage disposal systems were found to exist in many of the communities. The systems were all individual on-site arrangements ranging from direct discharge to roadside ditches, cesspools, privies, septic tanks, and to more recent septic tank and disposal beds which had failed due to inadequate design, improper installation, lack of maintenance, small lot dimensions, poor soil conditions, and high groundwater tables during winter. Water supplies were largely obtained from dug wells which in many cases were in danger of being contaminated or were contaminated from on-site disposal systems.

Conventional centralized collection systems and centralized sewage treatment plants were prohibitively expensive, resulting in average per household costs of $6,000 to $10,000. Even with the relatively high ratio of capital funding available from the Province at that time, net costs to the homeowner were in the range of $2,500 to $3,500.

The soils in selected areas surrounding the community were considered marginally suitable for on-site sewage disposal. The study concluded the Municipality should continue with on-site servicing and consider new concepts in off-site treatment with soil absorption and disposal through clustering of households. The community of Port Maitland was designated a priority area for pollution abatement and was selected as the pilot project for application of alternative soil absorption effluent disposal systems. From this background, the concept of the contour trench incorporating a cluster of homes was developed.

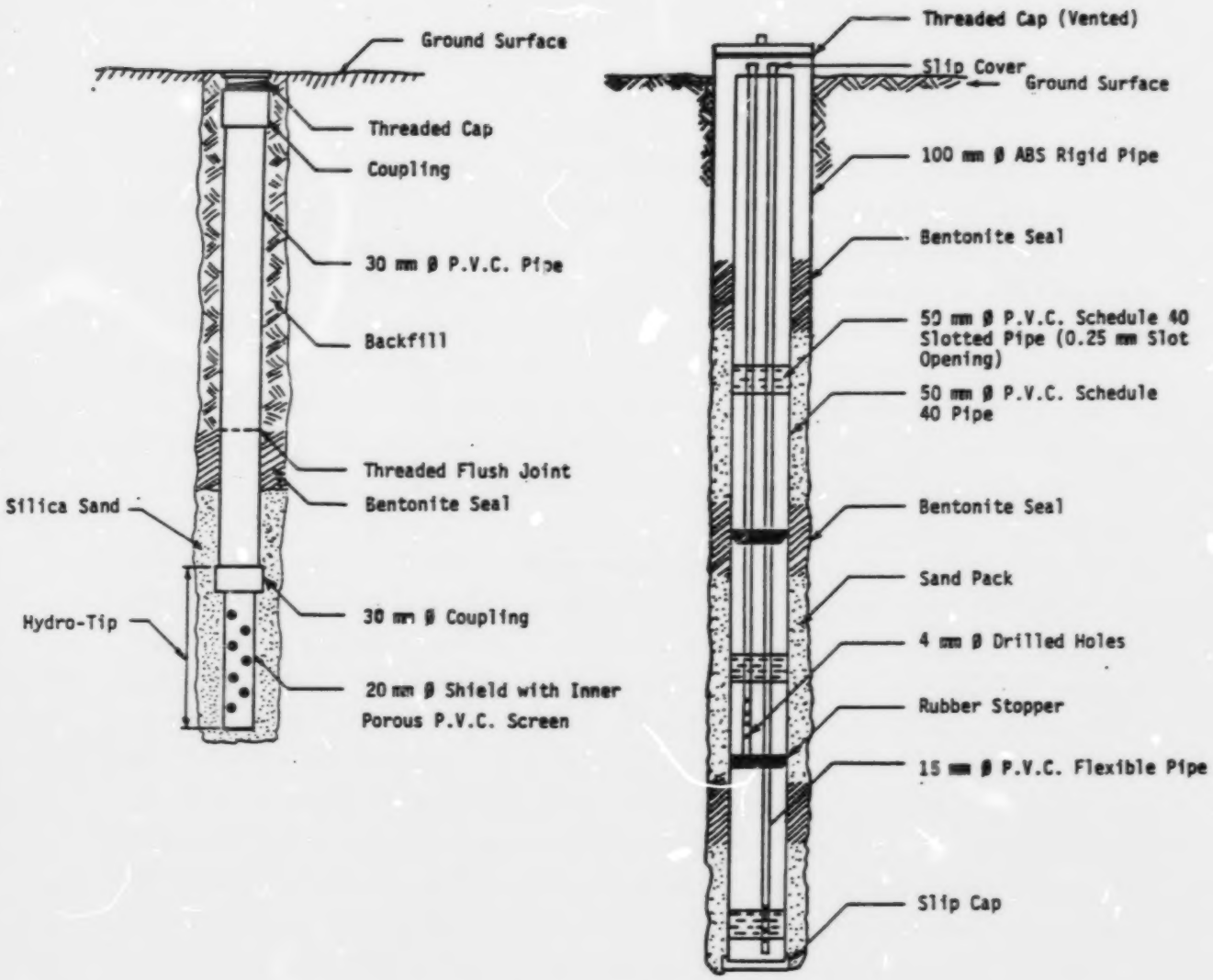
In 1982, the Municipal Act of Nova Scotia was amended to permit the creation of a municipally owned and operated utility to manage wastewater disposal systems within a designated area, referred to as a "Wastewater Management District", whether the facilities are privately or publicly owned. Port Maitland became the first Wastewater Management District in Nova Scotia and incorporated 120 households.

4.0 METHODOLOGY

The design and installation of 18 multi-level and single-level monitoring wells or piezometers started in December 1982. The investigation did not evaluate groundwater conditions prior to construction as the contract for the monitoring program was signed following the construction period. The entire study was limited to the area within a narrow easement due to property access problems which prevented installation of monitoring wells up gradient of the system. System B was selected for monitoring on the premise that the soil conditions represent the worst case of the four contour trench systems installed and typical of widespread soil conditions in Nova Scotia.

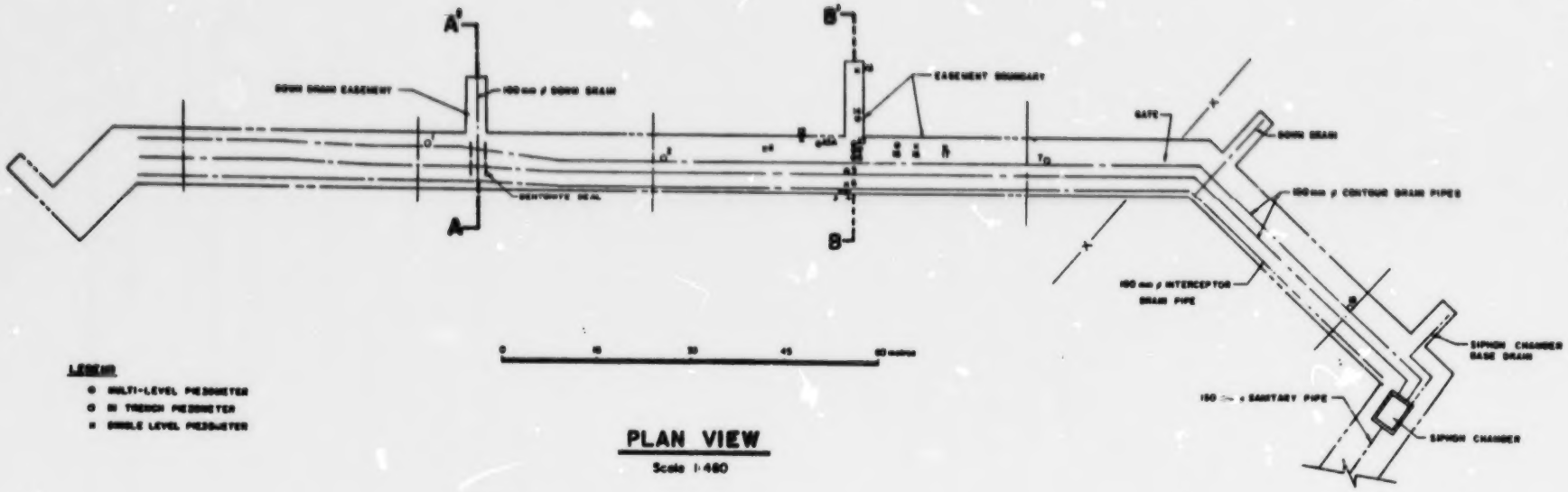
The multi-level piezometers were constructed of 50 mm diameter PVC pipe connected with threaded sections of slotted PVC pipe screen set to depths of 1.2 m, 2.7 m, and 4.3 m (Figure 3). The piezometer ports are designated shallow, intermediate and deep in Section 8 and Appendix A. The port slot openings were 0.25 mm. The internal sections were separated by rubber packers. Access to the lower two sections was obtained by using 15 mm diameter rigid PVC pipe set through the internal packers. The top of these pipes were painted for verification; blue representing the intermediate level and red the deep level. The shallow screen was accessed directly through the 50 mm pipe. Each multi-level piezometer was backfilled with No. 2 silica sand to specific levels where a bentonite seal was placed. Seals were placed to separate the sampling ports and to prevent surface water from entering the borehole. A 1 m section of 100 mm diameter conventional PVC sewer pipe was placed over the multi-level piezometer and bentonite sealed at the base to prevent frost action from lifting or damaging the piezometers.

The single level piezometers were constructed of 30 mm diameter Schedule 40 PVC pipe coupled to porous PVC sampling tips (Figure 3). Eleven of these piezometers were installed. Four of them (No. 1, 2, 7 and 18) were installed in the lower contour trench at depths of 0.8 m, 1.1 m, 1.3 m and 0.8 m respectively (Figure 4). The remainder (No. 3, 6, 11, 12, 13, 16 and 17) were installed at depths of 1 m, 1.3 m, 2.4 m, 4 m, 3 m, 3 m and 3 m



MULTI-LEVEL AND SINGLE-LEVEL PIEZOMETER DETAIL

FIGURE 3



PLAN VIEW

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CONTOUR TRENCH DESIGN PLAN

FIGURE 4

respectively. In the single level piezometers a bentonite seal was placed above the sand pack at 1 m depth. The remaining annulus was backfilled with native surficial material. Frost action did present minor problems to these installations.

Eight multi-level piezometers were installed. The spatial configuration is outlined in Figure 4. Piezometer No. 4 was placed through the upper interceptor trench, No. 5 between the upper and lower contour trench, No. 8, 9 and 10 spaced at 1 m intervals down gradient from the lower interceptor trench, No. 14 was placed a further 2 m down gradient from No. 10, No. 10A and 15 were placed parallel and down gradient from the lower contour trench on either side of piezometer No. 10. In order to prevent damage to the contour trench, the piezometers were inserted into boreholes drilled by a power auger mounted on an all terrain vehicle employing 100 mm diameter solid stem augers.

Water level measurements were taken on eight occasions over a two year period using a standard water level recorder and tape measure. All piezometers and measurements are surveyed to geodetic.

Water samples were taken on seven occasions over the same period using a peristalic pump and tygon tubing. Approximately 2 to 3 well volumes were removed from each chamber prior to sampling. The available time and slow recovery of the piezometers did not permit the extraction of additional well volumes. Standard sampling methods were not utilized due to extreme weather conditions and sample time limitations. The samples were not filtered in the field nor were preservatives added to fix nutrients. Sample delivery time was not always as desired due to the occurrence of extreme weather conditions and long travel time to the laboratory. Samples were collected in 1 litre plastic bottles and placed in coolers for shipment to the laboratory. The samples were filtered and all measurements were taken in the laboratory.

Although the majority of samples were clear, several samples of set 2 and set 3 were turbid and report high suspended solids and associated

metals (Appendix A). Caution in the interpretation of the relative concentrations of nitrogen compounds, pH, BOD and metals in turbid samples is advised. The description of the effluent plume is, however, well described by the major cations and anions and serves the purpose of this study.

5.0 OVERBURDEN

The Port Maitland area is underlain by Meguma Group slate and quartzite bedrock. The bedrock lies at depth in this community, covered by a thick drumlin till deposit. The elongated topographical high running parallel to the main community road consists of a complex of till types and overlying soils. System B was constructed over a moderate to highly compacted silty till, yellowish grey (Geological Survey of Canada rock color chart designation 5 YR 7/2), friable and containing varying amounts of pebbles, cobbles and small boulders. The silty till penetrated to a depth of 2.5 m where it is underlain by a compact sandy, silty till, dusky yellow (5 YR 6/4) containing broken subrounded cobbles and pebbles with minor amounts of quartzite pebbles. Several weathered zones located between 2.5 and 4.5 m depth were identified by reddish brown mottled till of higher permeability.

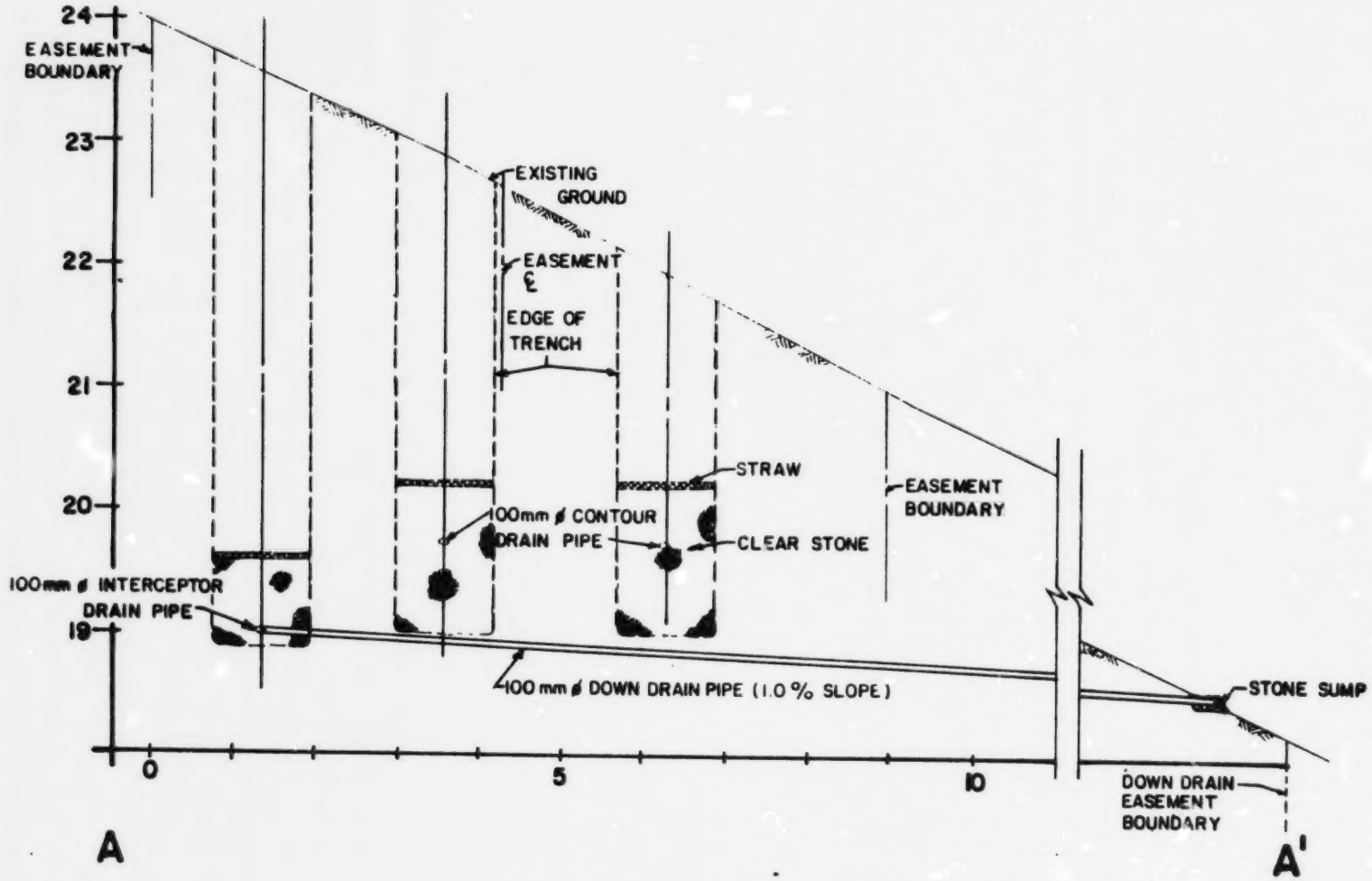
The soils derived from the underlying silty till consist of a moderate brown (5 YR 3/4) moderately compact silt with a total depth of approximately 0.6 m. A thin 5 to 8 cm section of sand was identified below the 10 cm depth root zone. This section was friable and contained numerous small pebbles. The lower section of the soil zone below the sand consisted of a weathered and mottled compact silt. Although the soil-till interface was very compact, the material was gritty and friable. It is probable that the upper soil horizon has a permeability several orders of magnitude greater than the underlying till, however, percolation test results indicate that System B is constructed in low permeability compact soils.

6.0 BASIC DESIGN

The following section briefly outlines the design parameters of the contour trench; specifically those pertaining to trench B which was selected for detailed monitoring. The contour trench B consists of three separate and parallel trench systems. The upper trench is identified as a shallow groundwater "interceptor". The two lower trenches are identified as "contour trenches". The entire system is set within a 9 m right-of-way easement (Figure 4).

The interceptor is excavated to a depth of 1.5 m and is 1.2 m in width. A 100 mm diameter PVC perforated interceptor drain pipe lies 200 mm above the base of the interceptor trench and is surrounded by Class B crushed stone. The stone extends 50 mm above the interceptor drain where it is covered by straw. Backfill excavated from the initial trench was placed over the straw and brought to grade. The interceptor discharges through 2, 100 mm diameter underdrains set at 1% grade. The underdrains lie perpendicular to and beneath the contour trench in two areas of extended easements (Figures 4 and 5). Placement of the underdrains required excavation across and through the contour trench. It was necessary to separate the underdrains from the contour trench through the installation of a thick bentonite seal to prevent leakage through the disturbed soil within the underdrain excavation.

The contour trench is of similar design, however, the depth of these two trenches remains 200 mm above the base elevation of the interceptor trench. The base elevations are constant, but trench depths vary due to differences in ground surface elevation. Each contour trench was fitted with a 100 mm diameter distribution pipe specially designed to distribute the hydraulic load evenly over the length of the trench. The initial section of the contour trench B contains a short section of solid PVC distribution pipe allowing transfer of the effluent from the siphon chamber to the desired contour elevation. The distribution of effluent in the pipe and loading rates from the pipe to the gravel trench are controlled by varying discharge orifice diameter and spacing along the distribution pipe. A computer model developed for the calculation of effluent distribution is described by Pask, 1983.



CONTOUR TRENCH CROSS-SECTION A-A'
FIGURE 5

The design of the contour disposal trench was based upon a number of assumptions. Following soil testing and standard percolation tests, a soil permeability was selected. Due to the lack of any correlation between standard percolation test results and soil permeability, the permeability value was essentially deduced from experience. Contour trench B was designed using the soil permeability of 1.4×10^{-5} m/sec. The hydraulic gradient was based upon surface gradients of 10% or 0.1. The loading (Q) was selected as an equivalent to 0.91 m^3/day/unit. Twenty four (24) homes were connected to trench B resulting in a total daily load of 21.84 m^3/day. The length of trench required was based upon permeability, daily loading and a factor of safety of approximately 1.4. The as-built length of contour trench B was set at 221 m.

Collection

The sewage is collected by 150 mm diameter PVC sewer main buried at shallow depth. The clustering principle allows shallow burial of collector systems due to the relatively short pipe run required. There were circumstances which required deeper burial, however, the majority of cluster B was buried below frost (1.2 m) and within a 2 m depth. A second feature of the collector system worthy of mention is that the sewer connector pipes were laid during construction and brought to within 1 m of the residential foundation walls. The entire contour trench system relies on gravity for effluent delivery. This feature is of particular interest due to the reduction in maintenance costs and simplicity of operation.

Septic Chambers

The septic chambers consist of precast sections of concrete assembled at the site. Contour trench B was constructed using two such tanks set in series. The upstream tank has a volume of 13.6 m^3 and the downstream tank has a volume of 7.2 m^3. The settled sludge is pumped periodically by vacuum trucks and removed for disposal. The frequency of cleanout is not yet determined.

Siphon

The siphon chamber, with its twin siphons, is designed to discharge a set volume of effluent of 5.46 m^3 four times daily. The system is designed to receive a total daily loading of 21.84 m^3. Each 0.35 m draught bell siphon discharges by first feeding the distribution pipe under initial 1 m head, gradually decreasing as the chamber is drained. Once the distribution pipe is full, the rate of discharge to the gravel bed is relatively constant until the siphon suction is broken. The siphon does not discharge again until the chamber critical depth is reached.

Each siphon loads a single trench which is controlled by means of a manual valve and slide gates at the siphon chamber. Each siphon discharges to its own trench and only one siphon and trench is in operation at any one time. The frequency of trench transfer was established as annual.

The system is vented through 100 mm diameter PVC riser pipes located on top of each siphon chamber.

7.0 SYSTEM HYDRAULICS

The complex response of the contour trench system to effluent loading is influenced by the effects of the interceptor trench, seasonal groundwater table elevations, high infiltration rates during precipitation events, temperate climatic conditions, variable soil permeabilities along the trench and certain design features. A first approximation of the operation is now understood and is described in Figure 6.

Chloride salts are generally considered a reasonable groundwater tracer due to the non-reactive qualities of this salt. During the period of investigation chlorides were observed to have migrated a distance of approximately 10 m over a one year period. If we assume that chlorides describe the advective groundwater transport, groundwater velocity approaches a value of 3×10^{-7} m/sec. Using the Darcy principle, $v = ki$, the soil permeability (k) approaches a value of 3×10^{-6} m/sec. under a hydraulic gradient (i) of 0.1. The calculated permeability is therefore less than the design permeability of 1.4×10^{-5} m/sec. at this location along the trench.

7.1 Discussion

Water level elevations in the piezometers recorded over the period of study are summarized in Table 1 with selected data described in Figures 7 and 8, Section 8.0. The maximum seasonal background fluctuation in head as expressed by results of piezometer No. 13 totals 1.45 m with the highest elevation recorded on May 10, 1984, and minimum elevation recorded on November 1, 1983 (Table 1). Piezometer No. 5A illustrates a fluctuation of 1.02 m and reflects the effects of sewage loading and infiltration over the trench area. Due to the disturbed condition of the backfill over the trench, high precipitation and frequent snow melt, the hydraulic response of the system during the spring and late fall is believed to more closely represent the effects of high surface infiltration. The June and November results define the system response to effluent loading, the effects of the interceptor trench and seasonally low water levels. The water level data indicate that high infiltration rates and corresponding high water level conditions are seasonal

TABLE 1
WATER LEVEL ELEVATIONS (m)
(GEODETIC)

Piezometer No.	Jan. 12/83	Jan. 26/83	March 31/83	June 16/83	Nov. 1/83	Feb. 16/84	May 10/84	August 9/84	Piezometer Surface Elevation
1	-	22.69	22.86	22.73	-	-	-	-	23.503
2	22.61	22.70	22.88	22.76	-	-	-	22.485	23.555
3	22.90	-	23.29	23.24	-	-	-	-	24.073
4A	22.82	23.00	22.91	22.74	22.52	22.99	23.041	22.531	24.006
4B	23.01	23.17	23.10	22.86	22.50	23.20	23.301	22.528	-
4C	22.91	23.10	23.05	22.80	22.43	23.18	23.254	22.428	-
5A	22.47	22.75	22.95	22.57	22.14	23.04	23.156	22.189	-
5B	22.46	22.74	22.78	22.57	22.13	23.03	23.156	22.190	23.604
5C	22.39	22.65	22.64	22.33	22.13	22.85	22.918	21.934	-
6	22.57	22.60	22.63	22.60	-	22.63	22.674	-	23.893
7	22.55	22.65	22.85	22.70	-	23.24	surface	-	23.592
8A	22.19	22.46	22.55	22.15	Dry	22.83	22.868	Dry	23.509
8B	22.19	22.45	22.51	22.12	21.68	22.78	22.826	21.607	-
8C	22.14	22.37	22.43	22.01	21.63	22.65	22.703	21.519	-
9A	22.09	22.39	22.43	22.00	Dry	22.74	22.756	21.696	23.366
9B	22.02	22.29	22.32	21.86	21.37	22.55	22.610	21.351	-
9C	22.00	22.27	22.31	21.84	21.34	22.54	22.560	21.323	-
10A	21.99	22.31	22.26	21.79	Dry	22.52	22.588	Dry	23.207
10B	21.98	22.29	22.26	21.76	21.24	22.51	22.553	21.207	-
10C	21.95	22.29	22.24	21.75	21.23	22.50	22.547	21.199	-
10AA	21.95	22.29	22.21	21.82	Dry	22.61	22.676	Dry	23.165
10AB	21.84	22.13	22.09	21.58	22.06	22.31	22.359	20.998	-
10AC	21.84	22.13	22.10	21.58	22.08	22.46	22.349	21.020	-
11	21.75	22.09	22.26	21.75	21.26	22.39	-	21.222	23.332
12	21.55	21.96	22.14	21.53	21.03	22.21	-	20.942	23.265
13	20.95	21.17	21.21	20.50	19.86	21.28	21.310	19.861	22.186
14A	21.88	22.13	22.12	21.50	Dry	22.23	22.428	Dry	22.860
14B	21.74	21.98	22.01	21.44	20.86	22.20	22.250	20.840	-
14C	21.68	21.93	21.99	21.43	20.83	22.17	22.222	20.825	-
15A	22.19	22.50	22.39	21.94	Dry	22.64	22.503	Dry	23.143
15B	22.11	22.34	22.36	21.93	21.41	22.78	22.490	21.428	-
15C	22.11	22.40	22.36	21.92	21.41	22.61	22.484	21.423	-
16	22.23	22.36	22.56	22.06	21.58	22.64	-	21.548	23.320
17	22.27	22.36	22.53	22.08	21.56	22.60	-	21.547	23.372
18	22.60	-	22.88	22.77	-	-	-	-	23.369

and prevent the contour trench from operating as intended for extended periods. The water level fluctuation of the first recession period was repeated in the second dry period of August 1984, suggesting that the results describe the general operating range of the contour trench. The results further illustrate the very shallow groundwater conditions prevalent in the till deposit and define the constraints which must be considered in future system design.

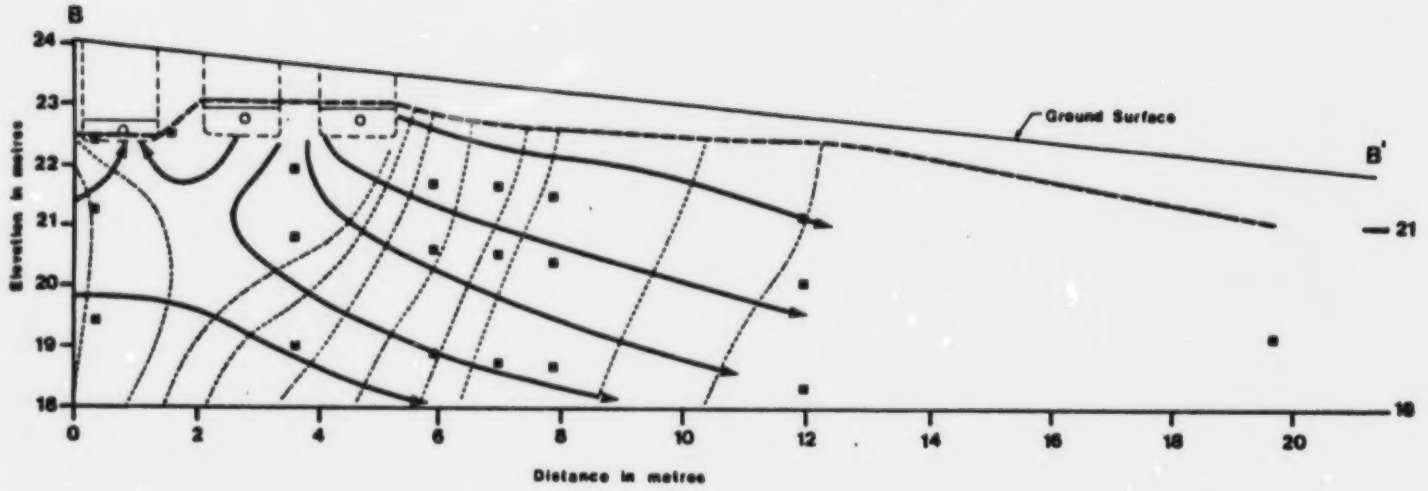
As the siphon discharges, water levels rise in the trench generating a shallow groundwater mound which rapidly dissipates with distance from the trench. The mound increases the hydraulic gradients in the area of the trench and increases the effluent-soil contact area resulting in improved effluent transfer from the trench to the soil. Average horizontal gradients approximated by measurements between piezometer No. 4 intermediate depth and piezometer No. 13 is 0.1 or is equivalent to the surface slope. Due to the changing saturation conditions within the trench, the vertical hydraulic gradients are highly variable, however, a general pattern is apparent. The vertical gradients within the shallow groundwater flow system are greatest immediately under the trench. As the trench recharges, the groundwater mound dissipates downslope under strong lateral gradients.

A preliminary interpretation of equipotential and flow lines is given in Figure 6. The water levels indicate that the interceptor trench causes shallow flow lines to converge toward the interceptor trench under high water level conditions. During the spring runoff period, dilute sewage effluent backflows to the interceptor trench and thus discharge to the surface via the interceptor downdrains. Water quality data (section 8) indicate that ammonia has discharged to the interceptor system.

The interceptor trench continued to discharge with the exception of the period July 1983 through November 1983 and June through October 1984, and following the heavy precipitation events . This is consistent with water level results given in Figure 4. Interceptor discharge rates vary between 0.075 to 0.38 L/sec. with the greater flows occuring during the spring melt and heavy precipitation periods. The interceptor discharge consists of both

groundwater inflow and surface infiltration to the trench. The relative components of total flow are not known. The major portion of flow is directed down gradient of the contour trench. Groundwater flow does not indicate breakthrough of the surface downslope of the contour trench system.

The hydraulic data indicate that the trench is submerged or saturated for extended periods. Although data are not available to confirm such conditions, anaerobic digestion may result in the development of "Black Mat" and clogging of the trench-soil interface. During the period of June to November, 1983, however, the saturated soils or shallow water table fell below the base of the trench allowing opportunity for oxygen enrichment and the development of aerobic bacterial activity and chemical oxidation which would inhibit the formation of bacterial slime.



LEGEND

- Equipotential Lines
- Flow Lines
- Water Table
- Measuring Point

GROUNDWATER FLOW SYSTEM
FIGURE 6

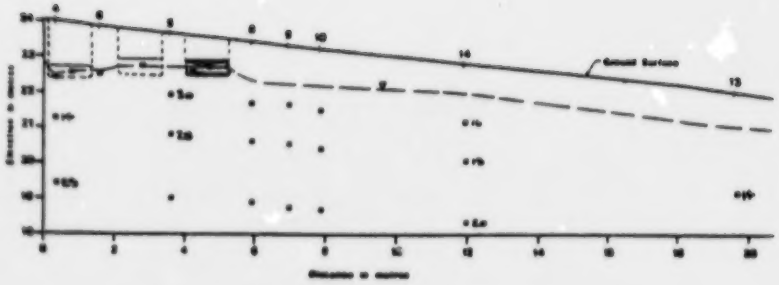
8.0 WATER QUALITY RESULTS

The distribution and pattern of effluent dispersement under and down gradient of the trench vary depending upon the parameter. The overall shape of the effluent plume is best described by the migration of chloride salts and the development of the effluent plume over time (Figure 7). Background chloride concentrations vary between 14 to 30 mg/l (data set 2, Appendix A) with highest concentrations immediately under the contour trench. Concentrations of chloride exceed 100 mg/l immediately beneath the contour trench decreasing rapidly with distance from the trench center. Data sets 4 and 5 describe a gradual increase in down gradient migration with a 50 mg/l concentration line extending beyond piezometer No. 14 (Figure 6). Maximum vertical penetration approaches a depth of 5 m below surface and approximately 2.5 m immediately below the bottom of the contour trench.

In general, the distribution patterns of other constitutents are similar to chloride as illustrated by alkalinity (Figure 8), however, concentration gradients differ and reflect the relative differences in concentrations of the raw effluent and soil attenuation processes. The migration patterns reveal that effluent penetration is gradual, is occurring both laterally and vertically and is principally confined to the lower till material.

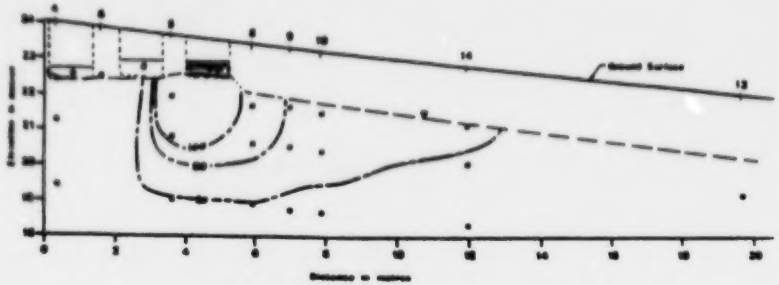
The most recent data (set 7, Appendix A, Figure 6) obtained during August 1984 illustrate that the lateral extent of the sewage may be traced to piezometer No. 14. The leading edge of the sewage plume lies between piezometers 13 and 14 and appears to have stabilized or reached an equilibrium condition between the sewage load and attenuating processes. Further monitoring is required to establish the maximum distance to steady state conditions.

The saturated and flooded conditions of the trench described in data set 5, Appendix A, may account for the extended limits of NH_4. The complete conversion of ammonia (NH_4) to nitrite (NO_2) nitrate (NO_3) does not appear to occur in the trench during this time suggesting the absence or lack of



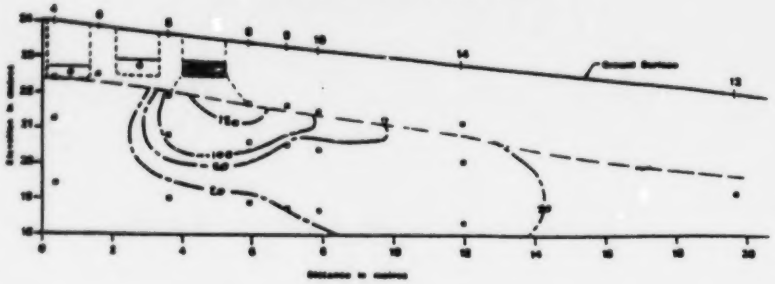
January 26,1983 - Set No.2 Background

February 16,1984 - Set No.5



June 16,1983 - Set No. 3

May 10,1984 - Set No.6



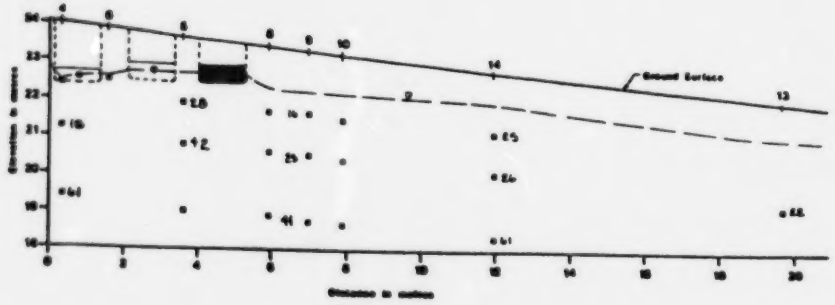
November 1,1983 - Set No.4

August 9,1984 - Set No.7

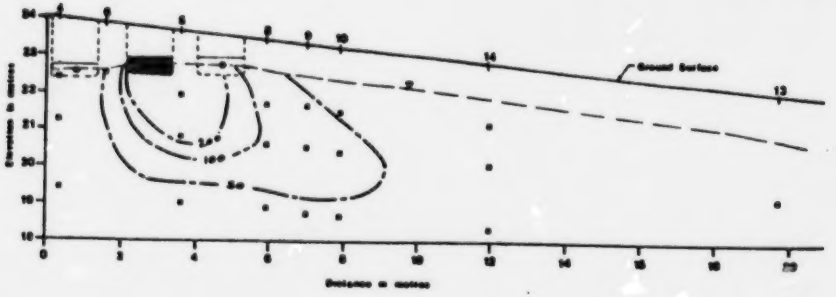
LEGEND

- Sample Port
- Waterlable
- Piezometer No. 4
- Trench in use
- Concentration mg/l

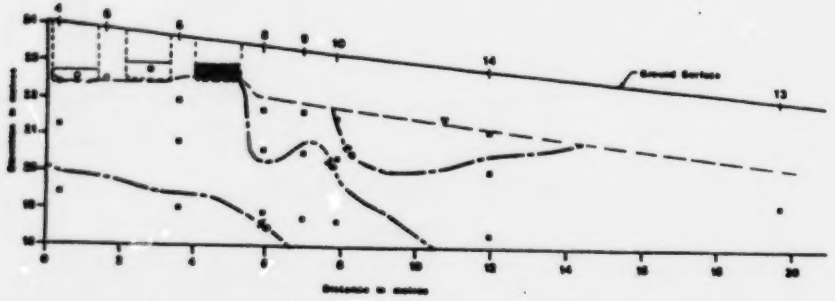
CHLORIDE CONCENTRATIONS mg/l
DATA SETS 2,3,4,5,6, and 7
FIGURE 7



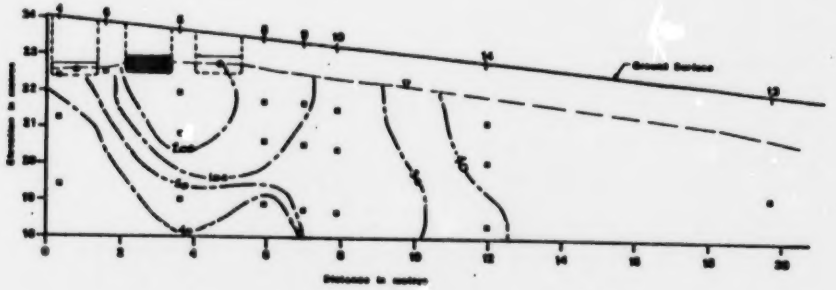
January 26,1983 - Set No.2 Background



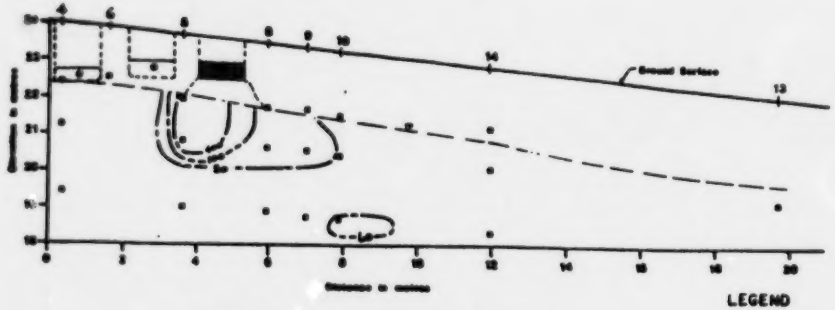
February 16,1984 - Set No.5



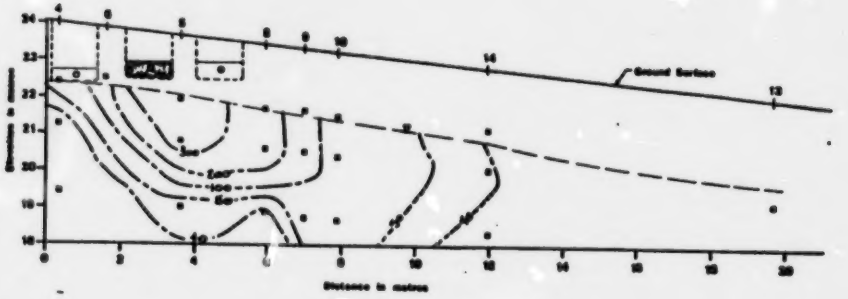
June 16,1983 - Set No. 3



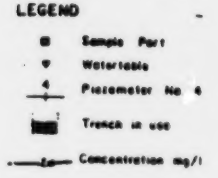
May 10,1984 - Set No.6



November 1,1983 - Set No.4



August 9,1984 - Set No.7



ALKALINITY CONCENTRATIONS mg/l
DATA SETS 2,3,4,5,6, and 7
FIGURE 8

oxygen. As the water level lowers allowing the trench to readily drain, the introduction of oxygen (O_2) may provide for the oxidation of NH_4 to NO_2 and NO_3 in the trench as suggested by the results of set 3 data (Appendix A). The degree of nitrification attributed to the soil medium is not known, however, complete conversion of NH_4 to NO_2 and NO_3 is suggested by the results described in set 3 and set 5 (Appendix A).

Ammonia, discharged from the interceptor system, vary in concentration from 0.05 mg/l in December 1982, to 86 mg/l in August 1984 (Data sets 1 and 7 respectively, Appendix A). The first appearance of NH_4 correlates closely to the transfer of effluent from the lower trench to the upper trench which occurred during January 1984. The discharge of NH_4 is a concern, however, alternating the upper and lower contour trench with seasonal groundwater table conditions is expected to reduce this problem. Regardless, the backflow of effluent to the interceptor trench illustrates the need for an alternate interceptor trench design.

9.0 CONCLUSIONS

1. The distribution of effluent within the soil closely correlates with the groundwater flow system configuration.

2. The shallow groundwater flow system and soil medium is providing a high degree of treatment and is effectively transmitting sewage effluent from the contour trench.

3. The contour trench system may operate under cyclic aerobic and anaerobic conditions. This possibility requires further evaluation.

4. A problem of periodic effluent breakout via backflow to the interceptor trench, during prolonged wet conditions, represents a design problem which requires assessment with specific attention to interceptor trench depth and separation distance.

5. The Port Maitland Contour Trench system has performed well under extreme test conditions. This unique type of disposal system has numerous applications all across Canada.

REFERENCES

Pask, D. 1983. A Contour Drain Disposal Field for Septic Tank Effluent in Low Permeability Soils. Master of Engineering Thesis, Technical University of Nova Scotia.

APPENDIX A

Water Quality Data

SAMPLE SET: 1 DATE SAMPLED: Dec.15/82	Downdrain 1	Downdrain 2							
DEPTH OF WELL:									
CHEMICAL PARAMETERS:									
Sodium mg/l	13.00	10.00							
Potassium mg/l	3.70	2.90							
Calcium mg/l	11.00	10.00							
Magnesium mg/l	3.10	3.00							
Hardness mg/l	40.00	37.00							
Alkalinity mg/l	22.00	19.00							
Sulfate mg/l	18.00	16.00							
Chloride mg/l	20.00	17.00							
Flouride mg/l	< 0.10	< 0.10							
Ortho-Phosphate mg/l	< 0.02	< 0.02							
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	3.55	2.74							
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	0.07	0.05							
Arsenic mg/l	< 0.005								
Iron mg/l	0.02								
Manganese mg/l	0.21								
Lead mg/l	< 0.002								
Copper mg/l	< 0.01								
Zinc mg/l	< 0.01								
TDS mg/l	110.00	101.00							
Suspended Solids mg/l	< 0.30	0.30							
Color T.C.U.	5.00	5.00							
Turbidity J.T.U.	0.52	0.44							
Conduct. Micromho/Cm	175.00	154.00							
pH Units	6.30	6.20							
TOC mg/l	2.70	2.70							
COD mg/l	7.00	28.00							
ODI mg/l	< 5.00								
BOD mg/l		< 2.00							
Humic Acids mg/l	4.80	3.50							
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	1.47	1.26							
Anions (meq/l) Total (Lab)	1.44	1.24							

SAMPLE SET: 2 DATE SAMPLED:Jan. 28/83	STATION 2	STATION 4		STATION 5		STATION 11	STATION 13		
DEPTH OF WELL:		Intermed.	Deep	Shallow	Intermed.				
CHEMICAL PARAMETERS:									
Sodium mg/l	83.00	11.00	21.00	21.00	24.00	10.00	40.00		
Potassium mg/l	4.80	1.80	8.50	1.50	3.50	2.20	1.40		
Calcium mg/l	12.00	5.40	11.00	15.00	14.00	6.50	5.30		
Magnesium mg/l	3.80	2.60	7.50	5.40	6.30	3.40	2.10		
Hardness mg/l	46.00	24.00	58.00	60.00	61.00	30.00	22.00		
Alkalinity mg/l	24.00	18.00	61.00	28.00	42.00	30.00	22.00		
Sulfate mg/l	135.00	12.00	27.00	18.00	25.00	9.30	61.00		
Chloride mg/l	26.00	14.00	23.00	30.00	25.00	14.00	14.00		
Flouride mg/l	< 0.10	< 0.10	0.20	< 0.10	< 0.10	< 0.10	< 0.10		
Silica mg/l	5.50	14.00	22.00	6.40	10.00	12.00	9.10		
Ortho-Phosphate mg/l	0.03	0.10	0.80	0.11	0.08	0.09	0.03		
Total Phosphate mg/l	0.30	0.40		0.50	0.02				
Nitrate + Nitrite mg/l	6.40	0.39	0.48	8.10	5.10	0.22	0.93		
Kjeldahl Nitrogen mg/l	1.50	0.80		0.50	0.40				
Ammonia mg/l	0.06	< 0.05	0.11	< 0.05	< 0.05	< 0.05	< 0.05		
Arsenic mg/l		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
Iron mg/l		1.50	11.00	0.10	2.70	0.14	0.49		
Manganese mg/l		0.05	0.41	0.96	1.20	1.20	0.23		
Lead mg/l		< 0.002	0.030	< 0.002	0.003	< 0.002	< 0.002		
Copper mg/l		< 0.01	0.03	0.02	< 0.01	0.01	< 0.01		
Zinc mg/l		0.02	0.04	0.03	0.01	0.02	0.03		
TDS mg/l		85.00	381.00	168.00	178.00	96.00	164.00		
Suspended Solids mg/l		4150.00	13210.00	13.90	1044.00	130.00	201.00		
Color T.C.U.		75.00	150.00	5.00	5.00	5.00	15.00		
Turbidity J.T.U.		84.00	260.00	1.50	23.00	4.10	5.50		
Conduct. Micromho/Cm		110.00	240.00	270.00	260.00	125.00	250.00		
pH Units	6.60	6.10	7.10	5.90	6.30	6.70	6.10		
TOC mg/l		1.30	2.70		2.70	19.00	2.40		
COD mg/l		< 1.00	< 5.00		6.00	92.00	< 1.00		
ODI mg/l		6.00	< 1.00		6.00	58.00	< 5.00		
BOD mg/l									
Aluminum mg/l		1.70	7.20	0.11	5.00	< 0.05	0.67		
Boron mg/l		0.06	0.04	0.04	0.07	< 0.02	0.05		
Barium mg/l		0.04	0.07	0.03	0.06	0.02	0.02		
Beryllium mg/l		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
Cadmium mg/l		< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		
Fecal Coliforms mg/l									
Cations (meq/l)									
sodium & potassium	3.72	0.53	0.55	0.95	1.00	1.10	0.47		
calcium	0.60	0.27	0.55	0.75	0.70	0.32	0.26		
magnesium	0.31	0.21	0.62	0.44	0.52	0.28	0.17		
total				2.14					
Anions (meq/l)									
sulphate	6.26	0.56	1.25	0.84	1.16	0.43	2.83		
chloride	0.73	0.39	0.65	0.85	0.71	0.39	0.39		
alkalinity	0.48	0.36	1.22	0.56	0.84	0.60	0.44		
total				2.25					

SAMPLE SET: 2 (Page 2) DATE SAMPLED: Jan. 28/83	STATION 14			STATION 15			STATION 17		
DEPTH OF WELL:	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep			
CHEMICAL PARAMETERS:									
Sodium mg/l	31.00	21.00	45.00	19.00	25.00	21.00	21.00		
Potassium mg/l	2.20	3.30	7.50	1.00	2.60	3.80	4.00		
Calcium mg/l	8.30	5.50	8.90	5.80	6.20	9.70	8.30		
Magnesium mg/l	2.80	3.30	6.20	2.10	3.00	4.90	4.30		
Hardness mg/l	32.00	27.00	48.00	23.00	28.00	44.00	38.00		
Alkalinity mg/l	25.00	26.00	61.00	16.00	25.00	41.00	32.00		
Sulfate mg/l	46.00	28.00	57.00	29.00	35.00	30.00	32.00		
Chloride mg/l	16.00	15.00	20.00	14.00	17.00	16.00	16.00		
Flouride mg/l	< 0.10	< 0.10	0.20	< 0.10	0.10	0.10	0.10		
Silica mg/l	5.10	12.00	17.00	5.80	13.00	18.00	18.00		
Ortho-Phosphate mg/l	0.05	0.15	0.40	0.03	0.15	0.09	< 0.02		
Total Phosphate mg/l	0.30	0.30	0.90	0.20	0.20	0.20			
Nitrate + Nitrite mg/l	2.20	0.65	0.43	0.66	0.86	0.60	0.77		
Kjeldahl Nitrogen mg/l	0.60	0.30	0.80	0.60	0.20	0.90			
Ammonia mg/l	< 0.05	< 0.05	0.11	< 0.05	< 0.05	< 0.05	< 0.05		
Arsenic mg/l	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
Iron mg/l	1.20	3.50	8.70	2.00	2.40	3.10	0.14		
Manganese mg/l	0.35	0.10	0.22	0.17	0.20	0.55	0.25		
Lead mg/l	0.003	0.003	0.020	0.004	0.010	0.003	< 0.002		
Copper mg/l	< 0.01	0.01	0.02	< 0.01	0.01	< 0.01	< 0.01		
Zinc mg/l	0.03	0.02	0.03	0.02	0.02	0.01	< 0.01		
TDS mg/l	156.00	173.00	448.00	135.00	232.00	161.00	130.00		
Suspended Solids mg/l	207.00	3430.00	1300.00	211.00	1547.00	1160.00	31.00		
Color T.C.U.	15.00	125.00		25.00	100.00	75.00	5.00		
Turbidity J.T.U.	9.80	60.00	190.00	14.00	66.00	38.00	2.20		
Conduct. Micromho/Cm	230.00	159.00	280.00	144.00	175.00	220.00	220.00		
pH Units	6.10	6.30	7.00	6.00	6.30	6.80	6.70		
TOC mg/l				2.70			1.90		
COD mg/l				< 1.00			< 1.00		
ODI mg/l				< 5.00			8.00		
BOD mg/l									
Aluminum mg/l	2.30	3.40	6.60	5.60	2.70	3.60	0.13		
Boron mg/l	0.04	0.04	0.04	0.04	0.02	0.06	0.02		
Barium mg/l	0.03	0.03	0.07	0.03	0.03	0.05	0.02		
Beryllium mg/l	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
Cadmium mg/l	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		
Fecal Coliforms mg/l									
Cations (meq/l)									
sodium & potassium	1.80	1.97	1.00	1.99	0.90	1.19	1.01		
calcium	0.41	1.43	0.44	0.17	0.31	0.48	0.41		
magnesium	0.23	0.27	0.51	0.29	0.25	0.40	0.35		
Anions (meq/l)									
sulphate	2.13	1.30	2.64	1.35	1.62	1.39	1.48		
chloride	0.45	0.42	0.56	0.39	0.48	0.45	0.45		
alkalinity	0.50	0.52	1.22	0.32	0.34	0.82	0.64		

SAMPLE SET: 3 DATE SAMPLED: June 16/83 June 17/83	STATION 2			STATION 4			STATION 5		
DEPTH OF WELL:		Downdrain #1	Downdrain #2	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	72.00	21.00	17.00	57.00	12.00	16.00	65.00	61.00	17.00
Potassium mg/l	14.00	2.60	1.60	2.40	1.50	2.70	2.10	2.10	2.70
Calcium mg/l	22.00	11.00	11.00	21.00	7.70	10.00	22.00	22.00	8.80
Magnesium mg/l	6.50	3.40	3.00	29.00	7.80	6.10	5.90	6.00	4.70
Hardness mg/l	81.70	41.47	39.82	171.86	51.35	50.09	79.23	79.64	41.33
Alkalinity mg/l	200.00	30.00	37.00	97.00	29.00	43.00	36.00	34.00	40.00
Sulfate mg/l	32.00	14.00	11.00	43.00	12.00	17.00	47.00	38.00	17.00
Chloride mg/l	100.00	32.00	31.00	18.00	11.00	17.00	115.00	106.00	18.00
Flouride mg/l	< 0.10	< 0.10	< 0.10	.20	< .10	< 0.10	< 0.10	< 0.10	< 0.10
Silica mg/l	7.10	9.40	6.50		12.90	19.30	7.70	7.70	18.20
Ortho-Phosphate mg/l	< 0.02	< 0.02	< 0.02	.46	0.03	0.05	< 0.02	< 0.02	< 0.02
Total Phosphate mg/l	0.20	0.10	0.20	1.60	3.90	0.20	0.40	< 0.02	< 0.02
Nitrate + Nitrite mg/l	< 0.05	2.40	1.16	< 0.05	0.53	0.22	< 0.05	< 0.05	0.53
Kjeldahl Nitrogen mg/l	19.00	0.90	1.30	0.80	0.90	0.70	0.20	0.90	0.30
Ammonia mg/l	18.00	0.46	0.66	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic mg/l	0.05	0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Iron mg/l	2.30	0.22	0.26	63.00	17.00	3.20	0.57	0.50	0.25
Manganese mg/l	18.92	< 0.09	3.19	1.18	0.50	0.24	8.38	5.48	0.50
Lead mg/l	< 0.002	< 0.002	< 0.002	0.090	0.030	0.008	< 0.002	0.005	< 0.002
Copper mg/l	0.02	0.01	< 0.01	0.15	0.50	0.01	0.03	< 0.01	< 0.01
Zinc mg/l	0.04	0.01	0.02	0.38	0.08	0.02	0.01	0.01	< 0.01
TDS mg/l	714.00	128.00	126.00		99.00	127.00	349.00	335.00	120.00
Suspended Solids mg/l	44.00	0.50	0.50	1640.00	1925.00	73.00	1.80	1.00	4.30
Color T.C.U.	65.00	5.04	5.00				10.00	10.00	5.00
Turbidity J.T.U.	4.70	0.64	0.65			21.00	2.00	1.40	2.60
Conduct. Micromho/Cm	770.00	240.00	230.00	310.00	110.00	179.00	570.00	540.00	176.00
pH Units	6.30	6.00	6.00	7.70	6.00	7.00	5.70	5.50	6.70
TOC mg/l	23.00	2.60	3.00	6.00	5.00	< 0.50	10.00	9.50	< 0.50
COD mg/l	68.00	8.00	26.00	57.00	70.00	15.00	41.00	38.00	7.00
ODI mg/l	40.00	6.00	6.00	6.00	18.00	6.00	24.00	24.00	6.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliforms mg/l									
Cations (meq/l) Total (Lab)	6.42	1.85	1.63	6.01	1.60	1.77	4.47	4.31	1.64
Anions (meq/l) Total (Lab)	7.48	1.96	1.93	3.34	1.18	1.71	4.94	4.46	1.70

SAMPLE SET: 3 (Page 2) DATE SAMPLED: June 16/83 June 17/83	STATION 8			STATION 9			STATION 10		
DEPTH OF WELL:	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	37.00	30.00	15.00	22.00	22.00	14.00	20.00	23.00	18.00
Potassium mg/l	1.20	1.20	3.80	1.20	4.00	3.50	0.90	1.10	4.60
Calcium mg/l	20.00	21.00	11.00	17.00	11.00	12.00	15.00	14.00	22.00
Magnesium mg/l	6.50	9.90	7.20	5.40	5.40	7.20	6.10	4.80	11.00
Hardness mg/l	76.71	93.21	57.12	64.69	53.82	59.61	62.58	54.73	100.23
Alkalinity mg/l	27.00	25.00	48.00	23.00	49.00	46.00	19.00	21.00	91.00
Sulfate mg/l	15.00	16.00	18.00	15.00	19.00	19.00	16.00	15.00	28.00
Chloride mg/l	70.00	63.00	21.00	48.00	22.00	18.00	37.00	35.00	15.00
Flouride mg/l	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.10
Silica mg/l	5.80	6.80	19.50	6.20	17.60	19.40	5.30	6.50	10.30
Ortho-Phosphate mg/l	< 0.02	0.04	0.03	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02
Total Phosphate mg/l	0.10	0.70	0.30	0.20	0.20	0.50	0.20	0.10	1.40
Nitrate + Nitrite mg/l	1.98	2.10	0.53	3.80	3.10	0.59	6.00	5.80	< 0.05
Kjeldahl Nitrogen mg/l	0.30	1.00	0.20	1.90	0.40	0.10	0.70	0.50	2.10
Ammonia mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic mg/l	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Iron mg/l	3.20	13.00	7.90	0.54	1.50	6.40	5.30	1.00	3.90
Manganese mg/l	0.32	0.47	0.23	0.39	0.78	0.32	0.29	0.28	1.16
Lead mg/l	0.006	0.030	0.004	< 0.002	0.003	0.002	0.050	0.010	0.007
Copper mg/l	< 0.01	0.03	0.02	0.01	< 0.01	0.02	0.02	0.01	0.02
Zinc mg/l	0.02	0.07	0.03	< 0.01	0.02	0.02	0.09	0.01	0.03
TDS mg/l	224.00	233.00	162.00	156.00	146.00	143.00	151.00	148.00	155.00
Suspended Solids mg/l	125.00	496.00	788.00	16.50	60.70	1070.00	166.00	49.50	478.00
Color T.C.U.	5.00	5.00		5.00	10.00			5.00	15.00
Turbidity J.T.U.	32.00	150.00	82.00	5.90	15.00	43.00	38.00	7.70	56.00
Conduct. Micromho/Cm	360.00	330.00	210.00	300.00	250.00	210.00	260.00	260.00	300.00
pH Units	5.70	5.70	6.70	5.90	6.60	7.00	6.10	5.70	7.30
TOC mg/l	2.80	2.20	< 0.50	1.80	1.20	< 0.50	2.00	1.60	1.20
COD mg/l	< 5.00	20.00	10.00	18.00	< 1.00	< 1.00	17.00	< 1.00	< 1.00
ODI mg/l	6.00	< 5.00	< 5.00	8.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	3.18	3.21	1.90	2.29	2.14	1.90	2.15	2.13	2.92
Anions (meq/l) Total (Lab)	2.97	2.76	1.96	2.40	2.22	1.87	2.18	2.13	2.83

SAMPLE SET: 3 (Page 3) DATE SAMPLED: June 16/83 June 17/83	STATION 11	STATION 12	STATION 13	STATION 14			STATION 15		
DEPTH OF WELL:				Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	8.00	12.00	14.00	20.00	13.00	17.00	22.00	15.00	14.00
Potassium mg/l	1.70	3.50	0.80	1.50	1.00	2.50	0.90	1.00	2.90
Calcium mg/l	5.50	8.70	3.40	15.00	6.30	6.30	12.00	7.80	8.30
Magnesium mg/l	3.40	4.10	1.40	4.90	3.30	4.40	4.70	3.30	4.40
Hardness mg/l	27.74	38.61	14.26	57.63	29.32	33.85	43.32	33.07	38.84
Alkalinity mg/l	24.00	25.00	19.00	11.00	19.00	25.00	15.00	20.00	33.00
Sulfate mg/l	5.40	7.20	14.00	16.00	12.00	17.00	31.00	12.00	15.00
Chloride mg/l	14.00	21.00	9.20	28.00	16.00	16.00	24.00	20.00	16.00
Flouride mg/l	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Silica mg/l	10.10	13.50	7.60	3.50	11.50	12.90	7.70	13.30	17.30
Ortho-Phosphate mg/l	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04	< 0.02	< 0.02	< 0.02
Total Phosphate mg/l	0.30	0.30	0.50	0.20	1.40	0.10	0.20	< 0.02	< 0.02
Nitrate + Nitrite mg/l	0.59	2.70	0.20	11.00	1.86	1.76	4.70	2.90	1.26
Kjeldahl Nitrogen mg/l	5.30	0.50	1.40	0.40	0.20	0.30	0.40	0.20	0.20
Ammonia mg/l	0.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.005	< 0.05
Arsenic mg/l	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Iron mg/l	0.21	0.58	1.30	0.84	1.30	4.30	3.20	0.72	0.32
Manganese mg/l	0.99	1.28	2.54	0.24	0.07	0.15	0.31	0.17	0.18
Lead mg/l	0.010	0.006	0.030	0.040	0.010	0.006	0.020	0.007	0.003
Copper mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.10	< 0.01
Zinc mg/l	0.05	< 0.01	0.04	0.04	< 0.01	0.02	0.04	0.01	< 0.01
TDS mg/l	62.00	94.00	56.00	151.00	84.00	121.00	156.00	99.00	95.00
Suspended Solids mg/l	32.30	33.70	70.50	24.70	192.00	99.50	108.00	23.80	7.00
Color T.C.U.	5.00	5.00	5.00	5.00	5.00	45.00	45.00	5.00	5.00
Turbidity J.T.U.	2.00	5.60	11.00	4.90	27.00	39.00	22.00	3.90	1.70
Conduct. Micromho/Cm	110.00	160.00	104.00	280.00	136.00	153.00	250.00	150.00	158.00
pH Units	6.60	6.20	6.20	5.90	6.10	6.30	6.00	5.90	6.60
TOC mg/l	18.00	1.20	1.20	0.70	< 0.50	0.70	1.60	0.70	< 0.50
COD mg/l	42.00	19.00	16.00	< 1.00	< 1.00	13.00	5.00	7.00	29.00
ODI mg/l	29.00	8.00	14.00	6.00	6.00	< 5.00	< 5.00	6.00	< 5.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	0.96	1.39	0.92	2.07	1.18	1.49	1.97	1.34	1.46
Anions (meq/l) Total (Lab)	1.03	1.43	0.95	2.13	1.21	1.43	1.96	1.42	1.51

SAMPLE SET: 3 (Page 4) DATE SAMPLED: June 16/83 June 17/83	STATION 16	STATION 17							
DEPTH OF WELL:									
CHEMICAL PARAMETERS:									
Sodium mg/l	12.00	14.00							
Potassium mg/l	1.80	2.60							
Calcium mg/l	8.20	8.70							
Magnesium mg/l	5.50	4.70							
Hardness mg/l	43.13	41.08							
Alkalinity mg/l	30.00	37.00							
Sulfate mg/l	11.00	15.00							
Chloride mg/l	16.00	16.00							
Flouride mg/l	< 0.10	< 0.10							
Silica mg/l	17.80	17.10							
Ortho-Phosphate mg/l	< 0.02	< 0.02							
Total Phosphate mg/l	0.60	0.10							
Nitrate + Nitrite mg/l	0.95	0.25							
Kjeldahl Nitrogen mg/l	0.70	1.70							
Ammonia mg/l	< 0.05	< 0.05							
Arsenic mg/l	< 0.005	< 0.005							
Iron mg/l	4.30	0.28							
Manganese mg/l	0.17	0.09							
Lead mg/l	0.009	0.005							
Copper mg/l	0.02	< 0.01							
Zinc mg/l	0.03	< 0.01							
TDS mg/l	91.00	99.00							
Suspended Solids mg/l	243.00	21.30							
Color T.C.U.	10.00	< 5.00							
Turbidity J.T.U.	130.00	2.10							
Conduct. Micromho/Cm	143.00	159.00							
pH Units	6.50	6.60							
TOC mg/l	1.80	1.80							
COD mg/l	66.00	34.00							
ODI mg/l	< 5.00	12.00							
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	1.44	1.50							
Anions (meq/l) Total (Lab)	1.35	1.52							

SAMPLE SET: 4 DATE SAMPLED: Nov. 1/83 Nov. 2/83	STATION 4		STATION 5		STATION 8			STATION 9	
DEPTH OF WELL:	Intermed.	Deep	Intermed.	Deep	Shallow	Intermed.	Deep	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	13.00	15.00	117.00	17.00	100.00	87.00	16.00	27.00	17.00
Potassium mg/l	1.30	2.90	17.00	2.90	8.10	3.50	3.30	5.20	3.00
Calcium mg/l	4.20	8.80	16.00	8.90	22.00	20.00	10.00	15.00	11.00
Magnesium mg/l	2.60	4.70	8.90	4.70	5.10	8.10	5.30	8.40	6.30
Hardness mg/l	21.19	41.33	76.60	41.58	76.50	83.30	46.80	72.05	53.41
Alkalinity mg/l	20.00	37.00	410.00	43.00	72.00	56.00	42.00	61.00	40.00
Sulfate mg/l	13.00	15.00	39.00	17.00	90.00	51.00	20.00	21.00	18.00
Chloride mg/l	12.00	16.00	127.00	18.00	140.00	119.00	18.00	43.00	23.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	< 0.02	< 0.02	< 0.02	1.10	0.11	0.03	< 0.02	< 0.02
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.23	0.39	< 0.05	0.44	< 0.50	0.14	0.44	1.31	0.44
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	< 0.05	< 0.05	75.00	< 0.05	0.10	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic mg/l									
Iron mg/l	1.50	0.21	25.00	0.10	53.00	5.50	0.21	0.31	1.10
Manganese mg/l	0.04	0.06	26.61	0.42	3.74	5.21	0.08	0.95	0.15
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	61.00	115.00	525.00	108.00		356.00	122.00	187.00	136.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	101.00	156.00	1250.00	170.00	610.00	600.00	175.00	300.00	210.00
pH Units	6.00	6.80	6.40	6.50	6.50	5.60	7.10	6.50	6.60
TOC mg/l	0.90	0.60	28.50	1.30	14.00	10.00	1.30	1.70	0.90
COD mg/l	< 1.00	< 1.00	90.00	< 1.00		56.00	< 1.00	7.00	< 1.00
ODI mg/l	< 5.00	< 5.00	56.00	< 5.00		16.00	< 5.00	< 5.00	< 5.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	1.03	1.56	12.42	1.65	6.09	5.55	1.72	2.76	1.89
Anions (meq/l) Total (Lab)	1.03	1.53	12.59	1.75	7.26	5.54	1.80	2.96	1.85

SAMPLE SET: 4 (Page 2) DATE SAMPLED: Nov. 1/83 Nov. 2/83	STATION 10			STATION 10A	STATION 14		STATION 15		
DEPTH OF WELL:	Shallow	Intermed.	Deep	Intermed.	Intermed.	Deep	Intermed.	Deep	
CHEMICAL PARAMETERS:									
Sodium mg/l	75.00	22.00	18.00	22.00	18.00	22.00	23.00	14.00	
Potassium mg/l	2.50	2.10	4.50	2.40	1.80	3.20	2.00	2.60	
Calcium mg/l	19.00	10.00	16.00	19.00	9.50	8.00	12.00	8.70	
Magnesium mg/l	5.10	4.30	8.40	9.10	4.70	4.40	5.90	4.70	
Hardness mg/l	68.45	42.68	74.54	84.92	43.08	38.10	54.26	41.08	
Alkalinity mg/l	41.00	34.00	63.00	45.00	19.00	26.00	26.00	32.00	
Sulfate mg/l	64.00	20.00	28.00	10.00	12.00	15.00	10.00	16.00	
Chloride mg/l	96.00	28.00	16.00	57.00	32.00	29.00	50.00	19.00	
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	0.02	0.03	< 0.02	0.07	0.02	0.03	< 0.02	
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.34	0.63	0.21	0.67	2.00	1.88	1.10	0.74	
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Arsenic mg/l									
Iron mg/l	0.81	1.40	5.10	0.20	0.16	1.20	0.34	0.15	
Manganese mg/l	5.80	0.65	0.71	0.16	0.05	0.24	0.27	0.12	
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	319.00	142.00	151.00	193.00	120.00	145.00	164.00	113.00	
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	550.00	200.00	240.00	310.00	220.00	200.00	270.00	156.00	
pH Units	5.70	6.20	7.10	5.90	6.00	6.40	5.90	6.70	
TOC mg/l	9.00	2.10	2.40	1.90	1.30	1.30	1.70	1.50	
COD mg/l	32.00	7.00	23.00	6.00	< 1.00	7.00	< 1.00	< 1.00	
ODI mg/l	20.00	5.00	12.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	4.70	1.87	2.40	2.73	1.70	1.81	2.14	1.50	
Anions (meq/l) Total (Lab)	4.88	1.93	2.31	2.76	1.67	1.78	2.22	1.56	

SAMPLE SET: 4 (Page 3) DATE SAMPLED: Nov. 1/83 Nov. 2/83	STATION 16	STATION 17	SYPHON CHAMBER						
DEPTH OF WELL:									
CHEMICAL PARAMETERS:									
Sodium mg/l	20.00	23.00	114.00						
Potassium mg/l	2.90	3.50	35.00						
Calcium mg/l	19.00	19.00	33.00						
Magnesium mg/l	11.00	9.80	12.00						
Hardness mg/l	92.74	87.80	131.82						
Alkalinity mg/l	61.00	56.00	515.00						
Sulfate mg/l	12.00	12.00	66.00						
Chloride mg/l	45.00	50.00	127.00						
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	< 0.02	37.00						
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	1.01	1.14	< 0.20						
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	< 0.05	< 0.05	98.00						
Arsenic mg/l									
Iron mg/l	0.16	0.11	0.65						
Manganese mg/l	0.04	0.12	0.20						
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	192.00	179.00	632.00						
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	320.00	310.00	1510.00						
pH Units	6.20	6.50	7.50						
TOC mg/l	1.70	1.50	50.00						
COD mg/l	< 1.00	< 1.00	579.00						
ODI mg/l	< 5.00	< 5.00	252.00						
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	2.81	2.86	15.50						
Anions (meq/l) Total (Lab)	2.81	2.86	15.25						

SAMPLE SET: 5 DATE SAMPLED:Feb. 16/84	DOWNDRAIN 1	DOWNDRAIN 2	STATION 4			STATION 5			STATION 6
DEPTH OF WELL:			Shallow	Intermed.	Deep	Shallow	Intermed.	Deep	
CHEMICAL PARAMETERS:									
Sodium mg/l	19.00	24.00	32.00	11.00	13.00	65.00	63.00	18.00	34.00
Potassium mg/l	3.40	4.10	2.30	1.00	1.90	9.90	9.40	2.50	3.40
Calcium mg/l	7.40	8.50	8.20	5.20	9.10	9.90	11.00	9.00	5.90
Magnesium mg/l	2.50	2.70	3.10	3.10	5.10	5.70	5.80	4.90	2.70
Hardness mg/l	28.77	32.34	33.24	25.75	43.73	48.19	51.35	42.65	25.85
Alkalinity mg/l	45.00	77.00	45.00	21.00	37.00	225.00	228.00	49.00	63.00
Sulfate mg/l	10.00	8.20	9.50	9.50	16.00	8.10	7.00	13.00	4.10
Chloride mg/l	29.00	37.00	12.00	10.00	15.00	100.00	102.00	18.00	51.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	0.52	0.08	0.33	0.11	0.03	< 0.02	0.02	0.03	< 0.02
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.94	< 0.05	2.30	0.36	0.52	< 0.05	< 0.05	0.56	0.20
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	5.70	10.00	0.07	< 0.05	< 0.05	38.00	41.00	0.10	9.00
Arsenic mg/l									
Iron mg/l	1.30	5.10	1.70	1.10	0.07	46.00	51.00	0.05	10.00
Manganese mg/l	2.07	4.10	0.16	0.07	0.27	27.42	25.92	0.49	9.84
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	109.00	139.00	400.00	72.00	104.00	332.00	325.00	114.00	156.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	240.00	310.00	158.00	106.00	165.00	830.00	830.00	180.00	360.00
pH Units	6.30	6.40	7.40	6.10	7.00	6.60	6.60	6.60	6.60
TOC mg/l	5.10	6.90	2.20	1.00	8.00	24.00	25.00	1.50	8.20
COD mg/l	20.00	27.00	15.00	14.00	15.00	116.00	116.00	< 1.00	32.00
ODI mg/l	22.00	20.00	10.00	< 5.00	< 5.00	58.00	54.00	< 5.00	22.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	1.90	2.51	2.12	1.02	1.49	6.76	6.94	1.71	2.73
Anions (meq/l) Total (Lab)	1.99	2.75	1.60	1.93	1.53	7.49	7.58	1.80	2.80

SAMPLE SET: 5 (Page 2) DATE SAMPLED:Feb. 16/84	STATION 8			STATION 9			STATION 10		
DEPTH OF WELL:	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	55.00	59.00	13.00	50.00	43.00	16.00	41.00	50.00	30.00
Potassium mg/l	3.50	3.90	2.70	2.70	3.30	2.50	1.90	1.80	3.00
Calcium mg/l	12.00	14.00	9.90	13.00	20.00	12.00	11.00	12.00	20.00
Magnesium mg/l	4.20	5.40	5.00	4.80	11.00	6.50	4.00	4.40	10.00
Hardness mg/l	47.26	57.20	45.31	52.23	95.24	56.73	43.94	48.08	91.12
Alkalinity mg/l	86.00	96.00	41.00	77.00	69.00	50.00	46.00	54.00	44.00
Sulfate mg/l	20.00	21.00	18.00	23.00	21.00	18.00	25.00	30.00	9.10
Chloride mg/l	74.00	83.00	15.00	71.00	70.00	21.00	54.00	67.00	66.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	0.02	0.03	< 0.02	0.03	0.03	0.03	< 0.02	0.05
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.17	< 0.05	0.50	0.73	1.25	0.51	1.86	1.57	2.80
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	5.60	6.60	< 0.05	5.00	< 0.05	< 0.05	1.86	2.50	< 0.05
Arsenic mg/l									
Iron mg/l	3.50	5.10	0.35	2.60	0.11	0.13	0.73	0.68	0.16
Manganese mg/l	16.13	15.83	0.08	13.76	0.50	0.12	5.95	7.33	0.16
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	252.00	278.00	113.00	249.00	252.00	130.00	194.00	231.00	216.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	470.00	530.00	170.00	470.00	450.00	240.00	360.00	430.00	360.00
pH Units	6.10	6.10	6.90	6.10	6.00	6.70	5.90	5.90	5.90
TOC mg/l	13.00	13.00	1.20	11.00	3.50	1.20	6.90	8.20	1.70
COD mg/l	41.00	42.00	< 1.00	33.00	12.00	< 1.00	44.00	26.00	5.00
ODI mg/l	22.00	28.00	< 5.00	22.00	10.00	< 5.00	< 5.00	20.00	< 5.00
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	3.83	4.29	1.55	3.65	3.87	1.90	2.85	3.37	3.22
Anions (meq/l) Total (Lab)	4.23	4.70	1.65	4.07	3.88	2.00	3.09	3.70	3.13

SAMPLE SET: 5 (Page 3) DATE SAMPLED:Feb. 16/84	STATION 14			STATION 13					
DEPTH OF WELL:	Shallow	Intermed.	Deep						
CHEMICAL PARAMETERS:									
Sodium mg/l	14.00	23.00	30.00	14.00					
Potassium mg/l	1.00	1.90	3.00	0.80					
Calcium mg/l	9.20	19.00	19.00	4.30					
Magnesium mg/l	2.70	9.20	10.00	1.80					
Hardness mg/l	34.09	85.33	88.62	18.15					
Alkalinity mg/l	13.00	34.00	43.00	14.00					
Sulfate mg/l	10.00	9.10	10.00	9.10					
Chloride mg/l	23.00	63.00	65.00	17.00					
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	0.15	0.10	0.04					
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	3.70	3.00	2.90	1.13					
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	< 0.05	< 0.05	< 0.05	< 0.05					
Arsenic mg/l									
Iron mg/l	0.03	0.07	0.13	0.22					
Manganese mg/l	0.12	0.06	0.16	0.08					
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	100.00	194.00	209.00	69.00					
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	154.00	340.00	360.00	115.00					
pH Units	5.80	5.70	5.90	6.00					
TOC mg/l	2.20	1.70	1.70	1.30					
COD mg/l	9.00	< 1.00	5.00	7.00					
ODI mg/l	10.00	8.00	8.00	10.00					
BOD mg/l									
Aluminum mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
Cations (meq/l) Total (Lab)	1.32	2.77	3.17	1.00					
Anions (meq/l) Total (Lab)	1.38	2.86	3.11	1.03					

SAMPLE SET: 6 DATE SAMPLED: May 9-10, 1984	DOWNDRAIN 1	DOWNDRAIN 2	STATION 2	STATION 4			STATION 5		
DEPTH OF WELL:				Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:*									
Sodium mg/l									
Potassium mg/l	3.00	4.60	4.70	1.60	0.90	2.00	12.00	13.00	2.40
Calcium mg/l	7.90	0.10	5.80	5.90	5.00	9.30	8.40	9.60	8.80
Magnesium mg/l	2.60	0.05	1.90	2.10	2.90	5.20	4.90	5.20	5.00
Hardness mg/l	30.43	< 1.00	22.31	23.38	24.43	44.64	41.15	45.39	42.56
Alkalinity mg/l	43.00	75.00	70.00	45.00	22.00	36.00	264.00	264.00	44.00
Sulfate mg/l	9.40	2.80	4.00	12.00	11.00	15.00	5.60	4.40	12.00
Chloride mg/l	24.00	34.00	24.00	17.00	11.00	16.00	120.00	119.00	20.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	0.24	0.07	0.04	0.10	0.04	0.03	0.03	0.03	< 0.02
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.72	0.07	< 0.05	1.80	0.26	0.61	< 0.05	< 0.05	0.70
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	4.70	11.00	11.00	< 0.05	< 0.05	< 0.05	50.00	44.00	< 0.05
Arsenic mg/l									
Iron mg/l	7.58	0.19	10.00	0.54	0.71	0.13	39.42	49.68	0.20
Manganese mg/l	3.38	0.10	2.42	0.08	0.04	0.02	13.61	13.59	0.58
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	102.00	145.00	134.00	261.00	68.00	111.00	373.00	405.00	112.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	195.00	300.00	260.00	160.00	97.00	156.00	920.00	920.00	170.00
pH Units	6.20	6.20	6.40	6.41	6.00	6.76	6.40	6.40	6.40
TOC mg/l	5.10	11.00	15.00	2.20	1.30	0.80	64.00	60.00	1.80
COD mg/l	17.00	42.00	53.00	5.00	< 1.00	< 1.00	173.00	167.00	< 1.00
ODI mg/l	6.00	24.00	26.00	< 5.00	< 5.00	< 5.00	78.00	78.00	< 5.00
BOD mg/l	5.00	16.00	19.00		2.00		86.00	79.00	< 2.00
Total Nitrogen mg/l	6.70	17.00	17.00	2.60	0.34	0.61	62.00	61.00	0.78
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliforms mg/l									
* Incomplete Analysis									

SAMPLE SET: 6 (Page 2) DATE SAMPLED: May 9-10, 1984	STATION 8			STATION 9			STATION 10		
DEPTH OF WELL:	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:*									
Sodium mg/l									
Potassium mg/l	5.00	5.60	2.70	4.20	3.30	2.80	2.50	2.40	5.30
Calcium mg/l	12.00	12.00	10.00	10.00	22.00	14.00	11.00	12.00	25.00
Magnesium mg/l	5.00	5.40	5.50	4.60	13.00	8.00	4.20	4.60	12.00
Hardness mg/l	50.55	52.20	47.62	43.91	108.47	67.90	44.76	48.91	111.84
Alkalinity mg/l	138.00	170.00	39.00	150.00	76.00	53.00	64.00	70.00	98.00
Sulfate mg/l	14.00	12.00	15.00	16.00	17.00	15.00	17.00	19.00	24.00
Chloride mg/l	105.00	110.00	17.00	99.00	83.00	30.00	74.00	82.00	36.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	0.02	0.04	0.02	< 0.02	0.04	0.02	0.02	0.03	0.03
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	0.87	< 0.05	0.60	0.40	0.34	0.50	0.76	0.45	0.26
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	11.00	16.00	< 0.05	12.00	0.15	< 0.05	4.60	4.70	0.11
Arsenic mg/l									
Iron mg/l	10.74	14.96	0.62	2.95	0.08	0.41	1.45	1.56	0.81
Manganese mg/l	32.26	36.14	0.16	47.38	0.36	0.13	18.78	19.89	1.55
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	357.00	388.00	112.00	353.00	282.00	152.00	239.00	265.00	217.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	610.00	690.00	160.00	600.00	450.00	270.00	420.00	450.00	360.00
pH Units	6.10	6.10	6.70	6.30	5.90	6.25	5.90	5.90	6.78
TOC mg/l	30.00	30.00	1.30	17.00	5.80	1.30	11.00	11.00	3.00
COD mg/l	64.00	77.00	< 1.00	54.00	18.00	< 1.00	34.00	35.00	15.00
ODI mg/l	40.00	48.00	< 5.00	30.00	12.00	10.00	22.00	18.00	10.00
BOD mg/l	8.00	8.00	< 2.00	6.00	4.00		5.00	4.00	
Total Nitrogen mg/l	16.00	19.00	0.67	17.00	0.73	0.55	6.40	6.40	0.45
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
* Incomplete Analysis									

SAMPLE SET: 6 (Page 3) DATE SAMPLED: May 9-10, 1984	STATION 10A		STATION 13	STATION 14			STATION 15		STATION 7
DEPTH OF WELL:	Shallow	Intermed.		Shallow	Intermed.	Deep	Shallow	Intermed.	
CHEMICAL PARAMETERS:*									
Sodium mg/l									
Potassium mg/l	1.10	2.10	0.70	0.80	2.00	2.80	1.10	1.50	16.00
Calcium mg/l	17.00	24.00	3.60	6.50	21.00	22.00	13.00	18.00	16.00
Magnesium mg/l	3.00	11.00	1.60	1.90	10.00	11.00	3.60	6.90	5.20
Hardness mg/l	54.80	105.23	15.58	24.06	93.62	100.23	47.29	73.36	61.37
Alkalinity mg/l	32.00	53.00	16.00	13.00	36.00	45.00	22.00	36.00	252.00
Sulfate mg/l	7.50	21.00	9.40	8.80	11.00	11.00	21.00	17.00	1.60
Chloride mg/l	35.00	67.00	13.00	16.00	66.00	70.00	56.00	64.00	103.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	0.03	0.15	0.04	0.02	0.03	< 0.02	< 0.02	< 0.02	0.09
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	5.00	1.97	1.26	1.39	3.00	4.70	1.41	1.42	< 0.05
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	44.00
Arsenic mg/l									
Iron mg/l	0.32	0.15	0.23	0.45	< 0.02	0.05	0.34	0.23	20.49
Manganese mg/l	0.88	0.49	0.07	0.18	0.09	0.18	4.18	3.56	6.05
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	158.00	262.00	70.00	75.00	226.00	254.00	186.00	220.00	426.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	250.00	400.00	110.00	114.00	380.00	390.00	310.00	350.00	870.00
pH Units	5.68	5.64	5.84	5.64	5.48	5.60	5.44	5.59	6.80
TOC mg/l	3.00	4.00	1.80	3.30	2.60	2.60	3.70	3.70	75.00
COD mg/l	28.00	12.00	< 1.00	8.00	7.00	< 1.00	11.00	9.00	239.00
ODI mg/l	10.00	12.00	10.00	10.00	10.00	10.00	6.00	14.00	88.00
BOD mg/l									122.00
Total Nitrogen mg/l	6.30	3.00	2.10	2.60	4.90	4.70	2.40	2.40	61.00
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l									
* Incomplete Analysis									

SAMPLE SET: 7 DATE SAMPLED:Aug. 9-10, 1984	SYPHON CHAMBER	UNDERDRAIN 1	UNDERDRAIN 2	STATION 4			STATION 5		
DEPTH OF WELL:				Shallow	Intermed.	Deep	Shallow	Intermed.	Deep
CHEMICAL PARAMETERS:									
Sodium mg/l	115.00	20.00	109.00	65.00	13.00	14.00	113.00	111.00	17.00
Potassium mg/l	32.00	3.70	29.00	3.10	1.20	2.40	20.00	18.00	2.20
Calcium mg/l	27.00	14.00	22.00	9.50	4.70	8.60	9.40	9.90	8.20
Magnesium mg/l	8.90	4.60	7.40	15.00	2.50	4.90	5.90	5.40	4.50
Hardness mg/l	104.07	53.90	85.41	85.49	22.03	41.65	47.77	46.96	39.01
Alkalinity mg/l	478.00	43.00	440.00	88.00	20.00	37.00	392.00	375.00	43.00
Sulfate mg/l	39.00	17.00	28.00	18.00	11.00	13.00	3.00	1.60	11.00
Chloride mg/l	130.00	27.00	128.00	19.00	13.00	17.00	123.00	123.00	18.00
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	36.00	0.03	2.80	0.56	0.03	0.03	< 0.02	< 0.02	< 0.02
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	< 0.50	2.40	< 0.50	0.48	0.25	0.59	< 0.50	< 0.50	0.83
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	93.00	1.13	86.00	< 0.05	< 0.05	< 0.05	70.00	68.00	0.05
Arsenic mg/l									
Iron mg/l	0.84	0.04	5.70	34.00	0.38	0.84	4.00	26.00	0.15
Manganese mg/l	0.16	0.36	1.48	0.24	< 0.01	0.41	6.67	9.03	0.50
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	639.00	147.00	541.00	1202.00	68.00	118.00	462.00	487.00	111.00
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	1370.00	237.00	1250.00	259.00	113.00	162.00	1060.00	1140.00	172.00
pH Units	7.40	6.80	7.30	7.30	6.50	7.20	7.30	7.00	7.10
TOC mg/l	82.00	4.90	60.00	2.60	0.90	0.80	40.00	45.00	1.50
COD mg/l	221.00	11.00	250.00	13.00	< 1.00	< 1.00	110.00	110.00	< 1.00
ODI mg/l	200.00	19.00	136.00	< 5.00	8.00	8.00	82.00	86.00	8.00
BOD mg/l	327.00	3.00	138.00	12.00	< 2.00	< 2.00	21.00	32.00	< 2.00
Total Nitrogen mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l	<3000		<3000		0	2	0	0	0
Cations (meq/l) Total (Lab)	14.56	2.13	13.34	4.63	1.04	1.51	11.39	11.09	1.58
Anions (meq/l) Total (Lab)	14.03	2.15	12.99	2.70	1.01	1.53	11.37	11.00	1.66

SAMPLE SET: 7 (Page 2) DATE SAMPLED:Aug. 9-10, 1984	STATION 8		STATION 9		STATION 10		STATION 10A		
DEPTH OF WELL:	Intermed.	Deep	Intermed.	Deep	Intermed.	Deep	Intermed.	Deep	
CHEMICAL PARAMETERS:									
Sodium mg/l	91.00	14.00	54.00	20.00	41.00	21.00	27.00	13.00	
Potassium mg/l	8.00	2.80	3.50	2.80	2.10	5.10	2.30	3.50	
Calcium mg/l	11.00	9.80	22.00	15.00	6.70	21.00	18.00	14.00	
Magnesium mg/l	6.00	5.20	12.00	7.30	2.80	11.00	9.40	6.10	
Hardness mg/l	52.18	45.88	104.35	67.52	28.26	97.74	83.66	60.08	
Alkalinity mg/l	209.00	33.00	115.00	62.00	64.00	87.00	46.00	49.00	
Sulfate mg/l	14.00	14.00	15.00	14.00	14.00	20.00	20.00	15.00	
Chloride mg/l	103.00	17.00	66.00	29.00	45.00	26.00	60.00	19.00	
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	< 0.02	0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	0.04	
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	< 0.05	0.61	0.23	0.62	0.64	0.25	0.23	0.41	
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	27.00	0.05	0.63	< 0.05	4.30	0.08	0.05	< 0.05	
Arsenic mg/l									
Iron mg/l	2.80	1.30	0.04	0.03	1.90	0.48	0.04	0.57	
Manganese mg/l	19.22	0.12	0.48	0.09	14.14	1.34	0.41	0.45	
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	369.00	117.00	270.00	154.00	197.00	183.00	221.00	127.00	
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	586.00	168.00	474.00	252.00	321.00	312.00	342.00	198.00	
pH Units	7.20	7.30	6.60	7.00	6.80	7.70	6.30	7.50	
TOC mg/l	22.00	1.50	6.50	2.50	8.00	3.20	4.00	2.20	
COD mg/l	68.00	< 1.00	18.00	< 5.00	15.00	7.00	11.00	< 5.00	
ODI mg/l	50.00	< 5.00	19.00	12.00	22.00	12.00	19.00	8.00	
BOD mg/l	5.00	< 2.00	2.00	< 2.00	5.00	< 2.00	2.00	< 2.00	
Total Nitrogen mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l	8	0	0	0	0	0	0	0	
Cations (meq/l) Total (Lab)	7.14	1.61	4.58	2.30	2.71	3.02	2.92	1.86	
Anions (meq/l) Total (Lab)	7.37	1.47	4.49	2.39	2.88	2.91	3.04	1.86	

SAMPLE SET: 7 (Page 3) DATE SAMPLED:Aug. 9-10, 1984	STATION 13	STATION 14		STATION 15					
DEPTH OF WELL:		Intermed.	Deep	Intermed.	Deep				
CHEMICAL PARAMETERS:									
Sodium mg/l	10.00	33.00	27.00	25.00	16.00				
Potassium mg/l	1.30	2.90	2.20	2.00	2.60				
Calcium mg/l	4.30	20.00	19.00	16.00	14.00				
Magnesium mg/l	2.00	9.80	9.00	7.90	7.50				
Hardness mg/l	18.97	90.30	84.51	72.49	65.84				
Alkalinity mg/l	14.00	46.00	32.00	47.00	48.00				
Sulfate mg/l	10.00	17.00	15.00	16.00	12.00				
Chloride mg/l	15.00	68.00	68.00	52.00	31.00				
Flouride mg/l									
Silica mg/l									
Ortho-Phosphate mg/l	0.05	< 0.02	0.02	< 0.02	< 0.02				
Total Phosphate mg/l									
Nitrate + Nitrite mg/l	1.07	1.34	1.72	0.93	1.15				
Kjeldahl Nitrogen mg/l									
Ammonia mg/l	0.08	< 0.05	< 0.05	< 0.05	< 0.05				
Arsenic mg/l									
Iron mg/l	0.10	0.02	0.03	0.17	0.06				
Manganese mg/l	0.07	0.24	1.33	2.35	0.70				
Lead mg/l									
Copper mg/l									
Zinc mg/l									
TDS mg/l	63.00	254.00	251.00	211.00	153.00				
Suspended Solids mg/l									
Color T.C.U.									
Turbidity J.T.U.									
Conduct. Micromho/Cm	112.00	372.00	351.00	314.00	237.00				
pH Units	7.20	6.20	6.00	6.50	6.90				
TOC mg/l	1.60	3.40	3.40	3.10	1.60				
COD mg/l	6.00	7.00	11.00	5.00	< 5.00				
ODI mg/l	12.00	12.00	12.00	12.00	8.00				
BOD mg/l					< 2.00				
Total Nitrogen mg/l									
Boron mg/l									
Barium mg/l									
Beryllium mg/l									
Cadmium mg/l									
Fecal Coliform mg/l				70	0				
Cations (meq/l) Total (Lab)	0.86	3.33	2.93	2.60	2.09				
Anions (meq/l) Total (Lab)	0.99	3.29	2.99	2.80	2.17				